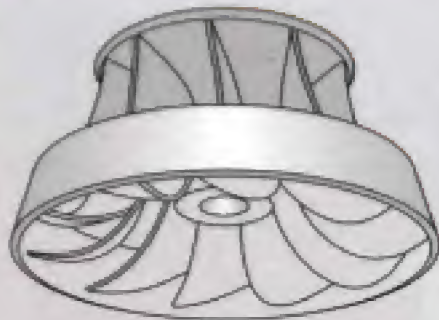


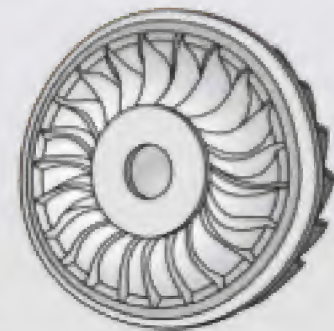
# Types of Hydropower Turbines



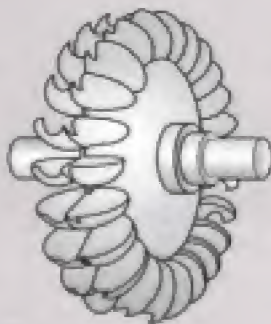
Francis



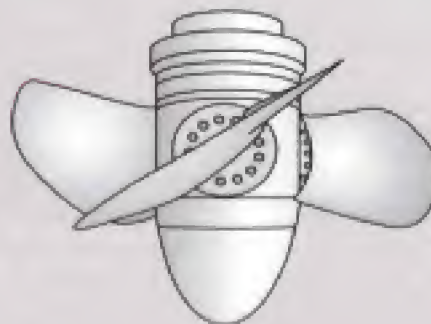
Fixed pitch propeller



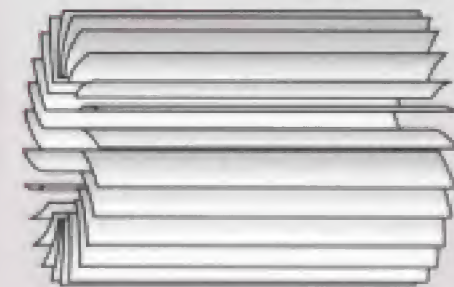
Turgo



Pelton



Kaplan



Crossflow

Figure 5.15 Types of turbine runner



# Idyllic, but Inefficient..





# Water Wheel History...

Water wheels of different types have been used for more than a thousand years to power mills of all types.

They were relatively inefficient.

Nineteenth century efficiency improvements of water turbines allowed them to replace nearly all water wheel applications and allow them to compete with steam power wherever water power was available.

Electric generators were developed in the late 1800's and turbines became a natural source of generator power, when potential hydro-power sources were at hand.

# **More of “As the Wheel Turns”...**

**In 1826 Benoit Fourneyron developed a high efficiency (80%) outward flow water turbine. Water was directed through the turbine RUNNER\*, causing it to spin.**

**\* The actual turning portion... the WHEEL**

**Jean-Victor Poncelet designed an inward flow turbine about 1820 that used the same principles.**

**S. B. Howd obtained a U.S. patent in 1838 for a similar turbine.**

# **A Little Then & Now...**

**In 1848 James B. Francis, head engineer of the Locks & Canals Co. in the water wheel powered textile factory city of Lowell Mass. improved upon the previous designs to obtain even greater efficiency.**

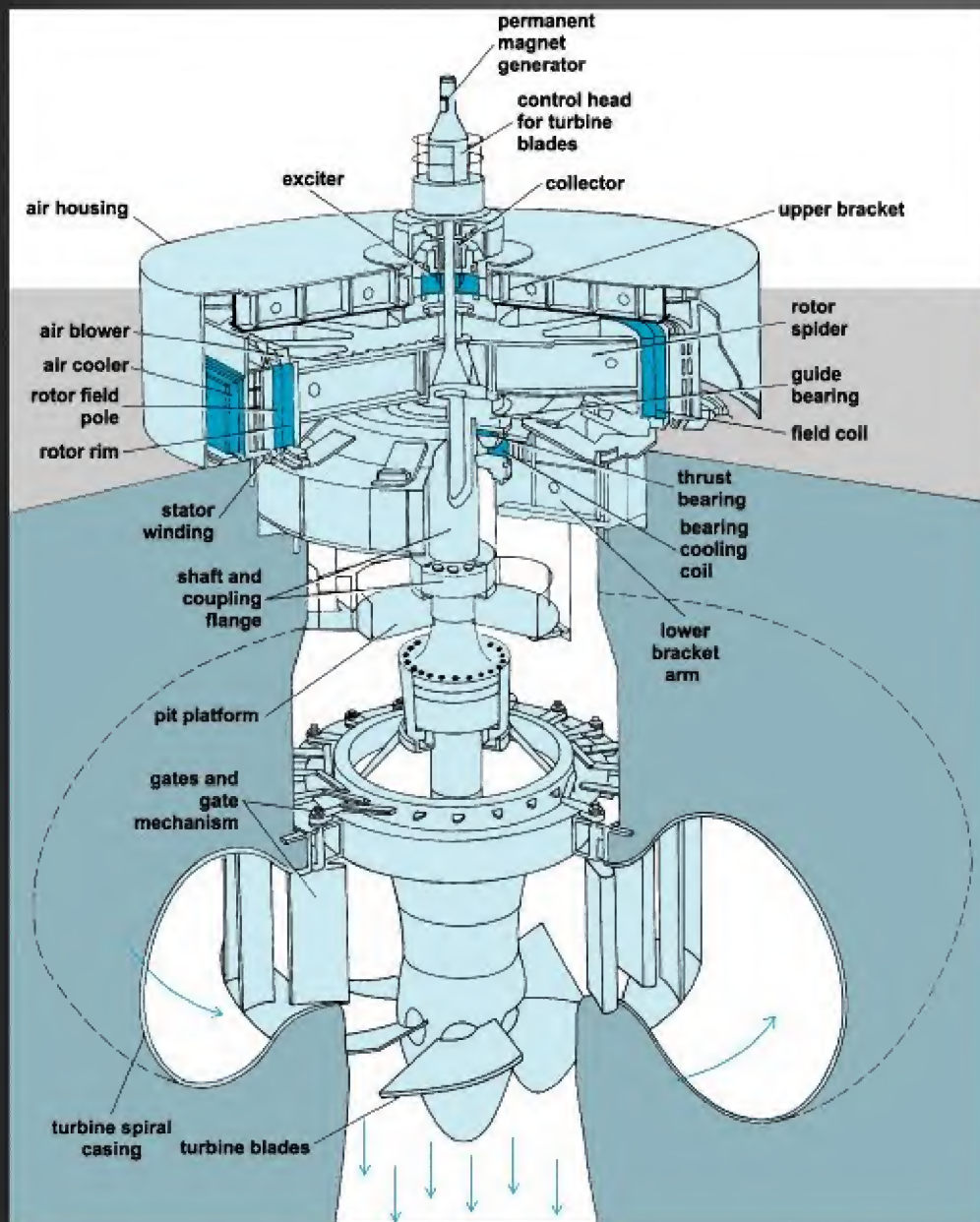
**His analytical methods allowed confident design to precisely match a site's flow and pressure (Water Head).**

**FRANCIS Turbines are currently used by Holyoke Gas & Electric to generate electricity at the Low Head Holyoke Dam and also, at the High Head Cobble Mountain Hydroelectric Generating Station on the Granville-Russell border, at the Little River.**



**James Bicheno Francis**





C O M P L  
O E  
P X  
T Y

While having the flexibility of variable pitch runner blades, A large amount of study has been done on bearing problems & power deficit due to cavitation loss

# Still NOT Simple

Note the  
combination  
of names;  
others will  
follow, also

Open Flume Setting of SMITH-KAPLAN Turbine

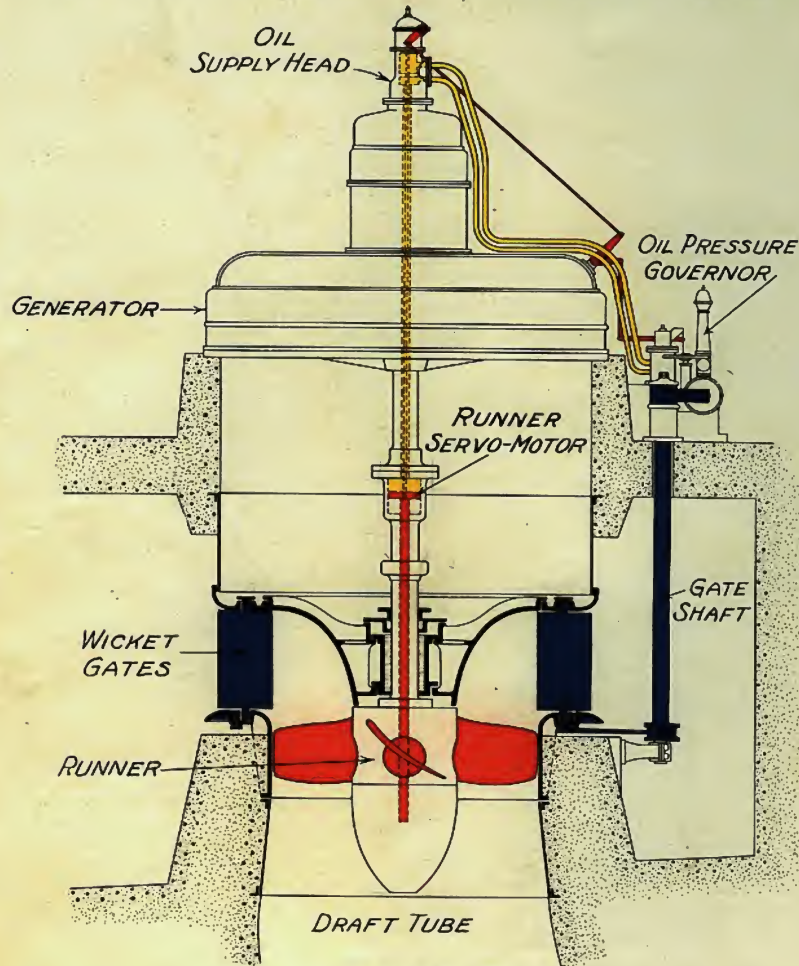


Figure 13

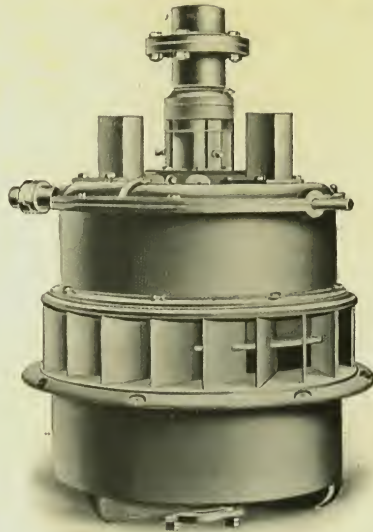
SMITH-KAPLAN TURBINES



CATALOG SECTION A B

Hunt-McCormick and Hunt-Francis  
Water Turbines

THIS Section contains table ratings from reliable tests for our Cylinder Gate Turbines. Type A and Type B reproduced from our Catalog No. 29 Section B. We furnish on request our Catalog Section H S illustrating a great variety of arrangements for setting Turbine Water Wheels.



TYPE A

Standard Cylinder Gate Casing fitted with the Hunt-Francis Runner. Regular enclosed Gate Rigging and Draft-Tube shown. Open Bale Step Support sometimes furnished. We make a specialty of Water Wheel Equipments for Central and South America Shipments. See Pages 20 to 25.

RODNEY HUNT MACHINE CO.  
ORANGE, MASS.



AGAIN...

Most of the old  
Makers names  
given me by  
Mr. Ducheney  
of Holyoke Gas  
& Electric are  
mentioned in  
the last 2 slides

ESTATE OF E. L. COOLEY

E. L. C.

<sup>v</sup>TREATISE

*Aug*

RELATIVE TO THE

Testing of Water-Wheels

AND

MACHINERY,

WITH

Various Other Matters Pertaining to Hydrodynamics.



BY JAMES EMERSON.

1881.

# While about Holyoke...

This was a Guide of the Selection of Turbines back in the latter half of the 19<sup>th</sup> Century as a “Treatise” by James Emerson, who performed testing of products of wheel makers in a Testing Flume at the Holyoke Dam. His work while based on his experience was similar to that of the earlier work of none other than James B. Francis whose son acknowledges Emerson’s work in the testimonial below.

---

## TESTIMONIALS.

---

OFFICE OF THE

PROPRIETOR OF THE LOCKS AND CANALS ON THE MERRIMAC RIVER,  
LOWELL, MASS., February 5, 1879.

JAMES EMERSON, Wilmansett, Mass.

Dear Sir: Your work on water wheels and machinery was left here yesterday by Mr. Swain.

My father (James B. Francis) is at present in Europe, and probably will not return before next August. I take the liberty to thank you for him, and to assure you that your book contains a fund of information of the kind we want. How to utilize water power to the best advantage is one of the great problems of the day, and I am sure you have contributed much information on the subject.

Very truly yours,

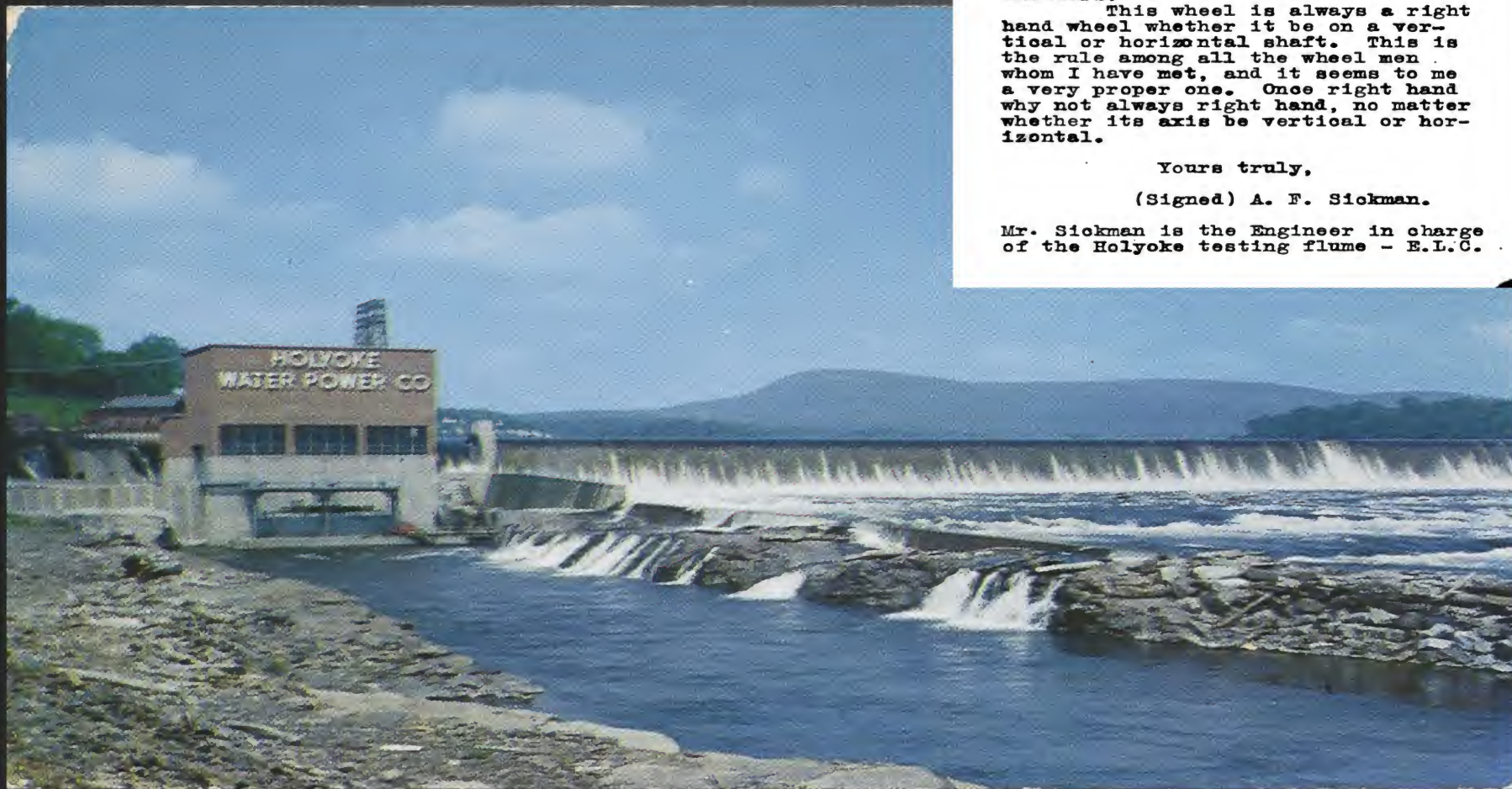
JAMES FRANCIS, *Ass't Engineer.*

---



# The Holyoke Dam

and a letter to E. L. Cooley,  
noted on the previous page



C O P Y

HOLYOKE WATER POWER CO.  
HOLYOKE, MASS.

February 11th, 1910.

The Sanitary District of Chicago,  
Chicago, Illinois.

Attention Mr. E. L. Cooley.

Gentlemen:-

The ordinary downward discharge single turbine turning in the direction of the hands of the clock is a "right hand wheel". I believe this is the rule among all turbine builders.

This wheel is always a right hand wheel whether it be on a vertical or horizontal shaft. This is the rule among all the wheel men whom I have met, and it seems to me a very proper one. Once right hand why not always right hand, no matter whether its axis be vertical or horizontal.

Yours truly,

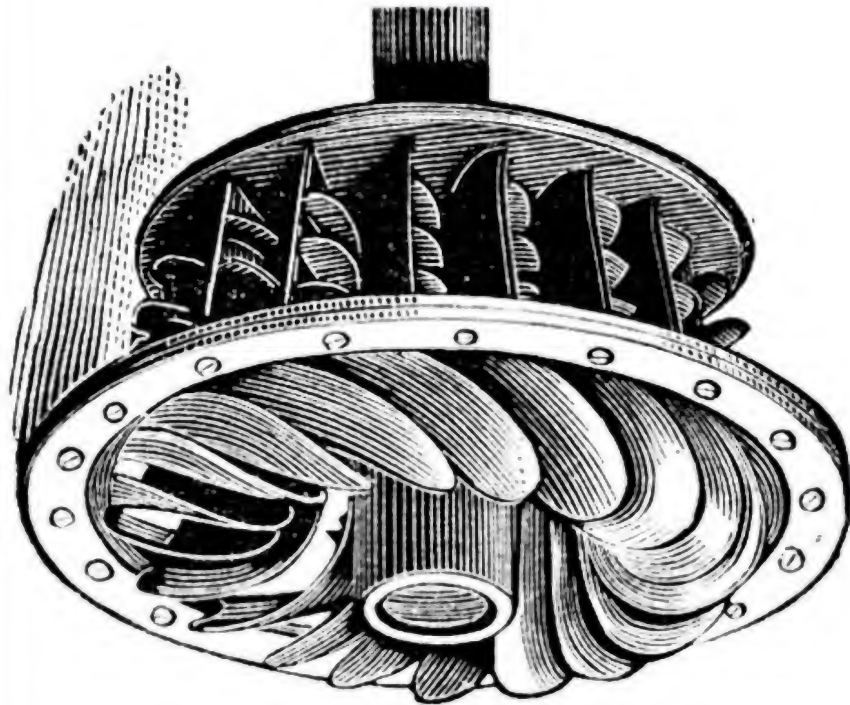
(Signed) A. F. Sickman.

Mr. Sickman is the Engineer in charge  
of the Holyoke testing flume - E.L.C.

# Some Holyoke Made Wheels

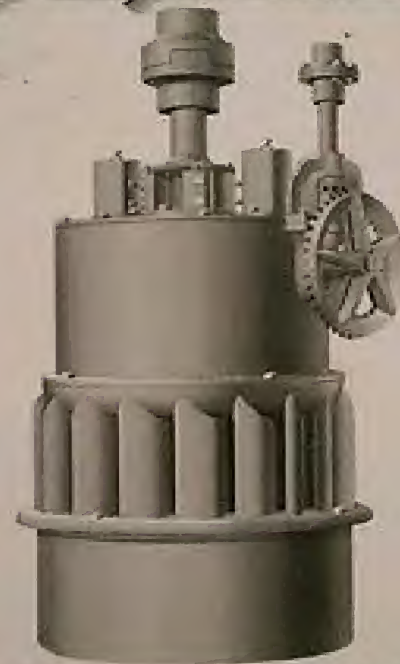
## Hercules Wheel.

*Holyoke Machine Co., Holyoke, Mass.*



*48-inch wheel.*

*"The Hercules"*



**HOLYOKE MACHINE CO.**  
**Holyoke, Mass. & Worcester, Mass.**



Cannot Speak too Highly of the Hercules Wheel.

JAMES RIDDLE, SON & CO.  
Brandywine Cotton Mills.

KENTMERE, DEL., April 27, 1887.

In reply to your inquiry as to the working of a "Hercules Water Wheel" now running at our mills, would say that we put in nearly two years ago a 39-inch Hercules Wheel, running under a 14½-foot head. It is driving up to full regular speed three hundred and three heavy looms, with only half gate. We are about to enlarge the weave mill and add three hundred more looms, which will be driven by the same wheel. We cannot speak too highly of the Hercules. It has absolutely run without cost or derangement since it started, and has given eminent satisfaction in every way.

Yours truly,  
JAMES RIDDLE, SON & CO.

Perfectly Satisfactory in Every Way.

PORTER WOOLEN MILL.  
J. H. Porter, President. J. W. Robertson, Gen. Manager.

CLARKSVILLE, GA., April 29, 1887.

In reply to enquiry as to my opinion of the Hercules Turbine Water Wheel, say: I have put in two, one about

putting up any more mills, would use the Hercules Wheel. They have given us perfect satisfaction.

Yours respectfully,

F. J. MINHINETT, Prest.

A Good Wheel, and Has Given Good Satisfaction.

PEE DEE MANUFACTURING CO.  
Plaids and Warps.

ROCKINGHAM, N. C., April 30, 1887.

We have been using the Hercules Water Wheel for more than six years. Our superintendent says it is a good wheel, has given good satisfaction, and its performance is equal to the claims of the maker. We have a head of 17 feet. Our wheel has a diameter of 39 inches. Under this water pressure the wheel has moved 4,000 spindles and the needed preparation, and 164 plaid looms. The above includes the dye house, machine shop and all other machinery which we employ.

Very respectfully,  
WALTER L. STEELE, Prest.

Best Wheels I Have Ever Seen.

MARIETTA PAPER MANUFACTURING CO.,  
Book, News and Wrapping Papers.

MARIETTA, GA., April 30, 1887.

In reply to your favor of the 25th inst.: I am using four Hercules Water Wheels, two 12-inch, one 24-inch,

ATHENS, GA., April 28, 1887.

I have used the "Hercules" wheel since 1881, and am so well satisfied with it that I should not purchase any other it in want of a first-class wheel. It does all the manufacturers claim for it.

Yours truly,  
WM. J. RUSSELL, Manager.

Has Given Entire Satisfaction.

HOLCUMB'S ROCK, BEDFORD CO., VA., }  
April 28, 1887.

The Hercules Wheel has given entire satisfaction.  
Very respectfully,

J. A. HARRIS & CO.

Unhesitatingly Say its the BOSS Wheel.

BUZELA, GA., April 29, 1887.

I have been using a 21-inch "Hercules Water Wheel" since August 1880, and unhesitatingly say it is the BOSS wheel. It has performed with utmost satisfaction, and given more power than the makers claim, using water with more economy than any wheel I ever knew. T. W. G. Inglett, Esq., who has put up two "Hercules" for parties, says "it can't be beat."

Very respectfully,  
BRAD. MERRY.

# THE HERCULES

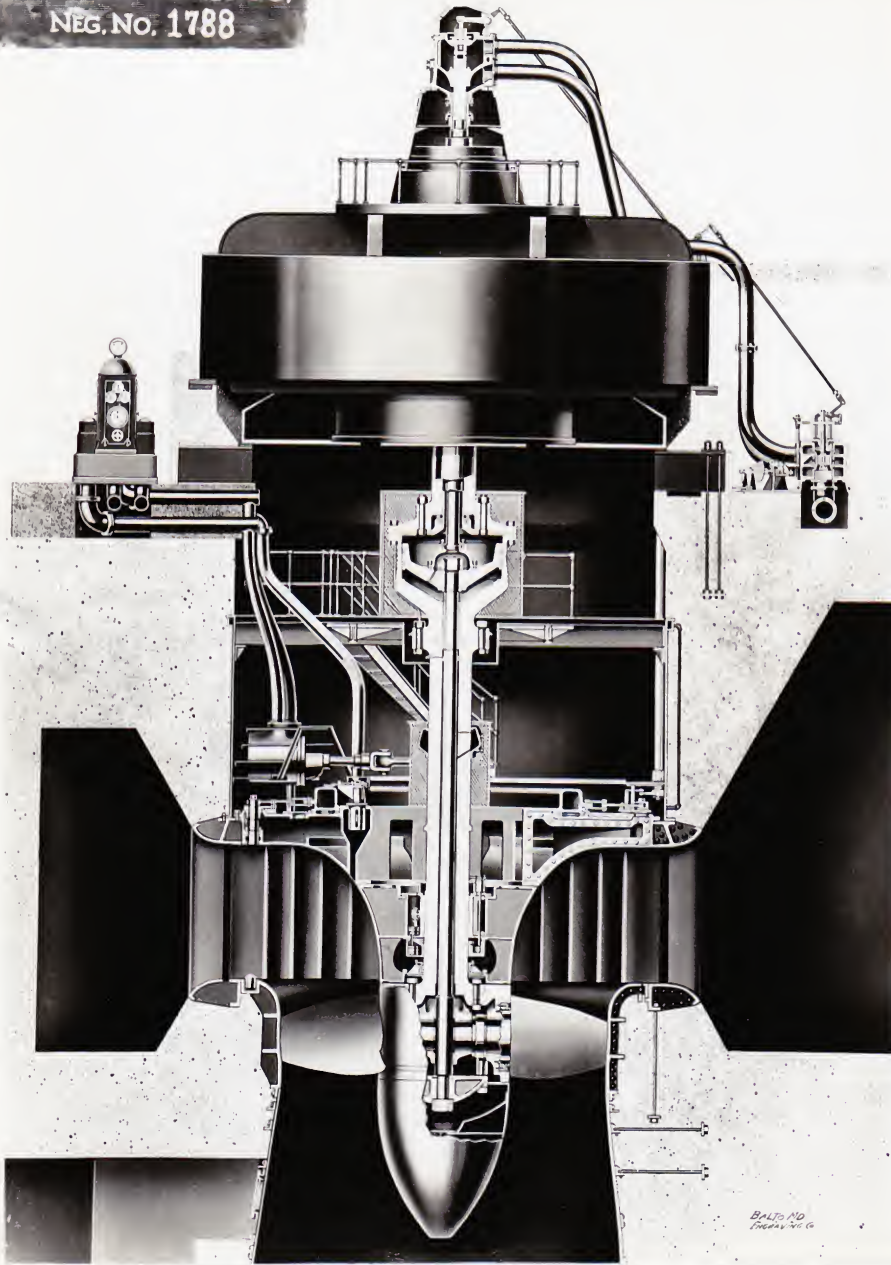
Gives the Most Power for its Size and the Highest Average Percentage from Full to One-Half Gate of Any Wheel Ever Made.

*If you want to buy a new Water Wheel, if your old wheel does not give satisfaction, if you would like to know just how perfect a Water Wheel can be made, or if you are in any way interested in Water Wheels it will pay you to write for Catalogue No. 3 to the*

## HOLYOKE MACHINE CO., Worcester, Mass.



S. MORGAN SMITH CO.  
NEG. NO. 1788



Yet Another  
respected turbine  
maker  
mentioned  
previously with  
Kaplan:

S. Morgan Smith



# A McCormick AD (top) & A Hunt Drawing (bottom)

January, 1906

THE CANADIAN ELECTRICAL NEWS

**Pair**

## **McCormick Turbines**

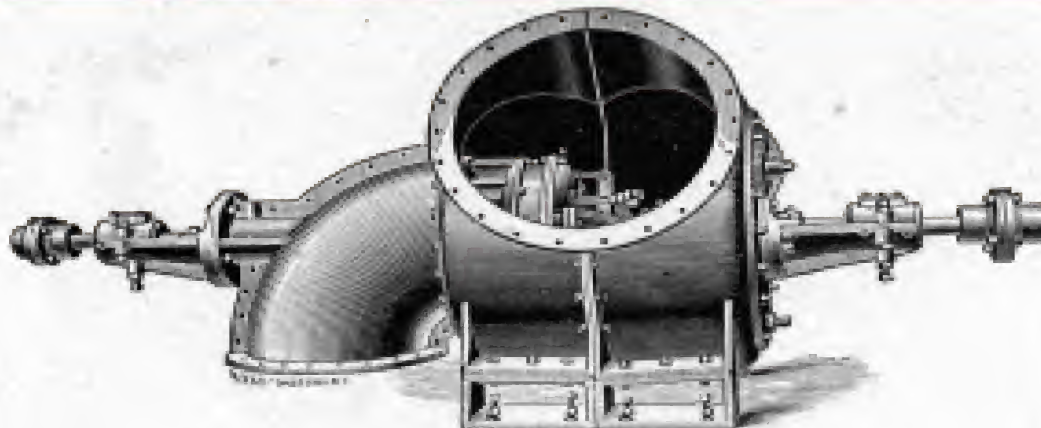
4,000 H. P., 80 ft. head, arranged to drive generator and a single turbine to drive exciter. Seven settings built for the Hudson River Water Power Company for their Spier Falls plant and 14 pairs 51 inch for their plant at Mechanicsville, N. Y.



## **S. Morgan Smith Company, York, Pa., U.S.A.**

Branch Office: 176 FEDERAL STREET, BOSTON, MASS.

Write for catalogue if contemplating purchase of Turbines



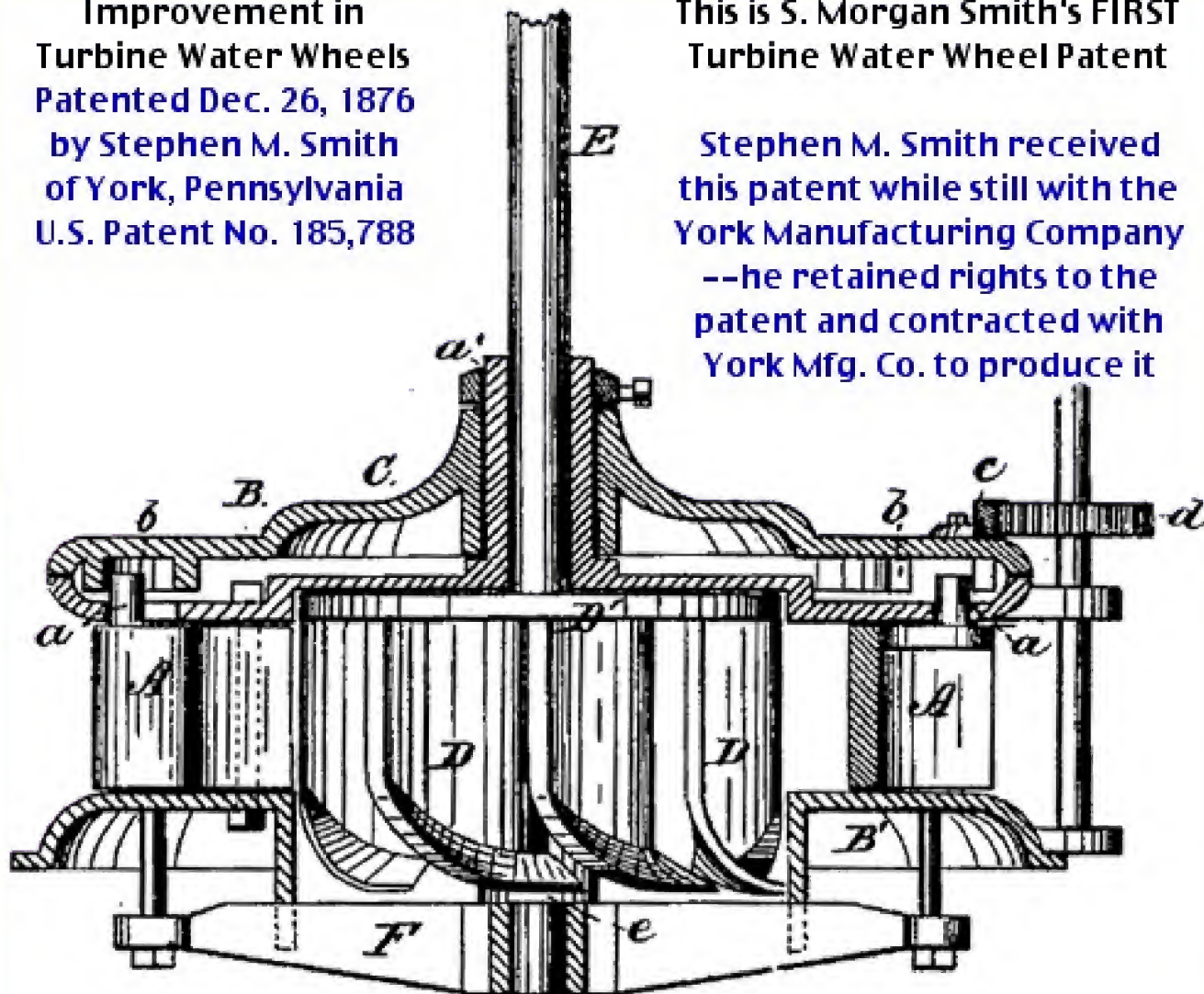
TURBINE WHEEL ON HORIZONTAL SHAFT.

# Stephen Morgan Smith's Turbine Wheel

Improvement in  
Turbine Water Wheels  
Patented Dec. 26, 1876  
by Stephen M. Smith  
of York, Pennsylvania  
U.S. Patent No. 185,788

This is S. Morgan Smith's FIRST  
Turbine Water Wheel Patent

Stephen M. Smith received  
this patent while still with the  
York Manufacturing Company  
--he retained rights to the  
patent and contracted with  
York Mfg. Co. to produce it





# How much force may be lost in discharge?

(remember 'cavitation') This similar to Holyoke with 35 foot head

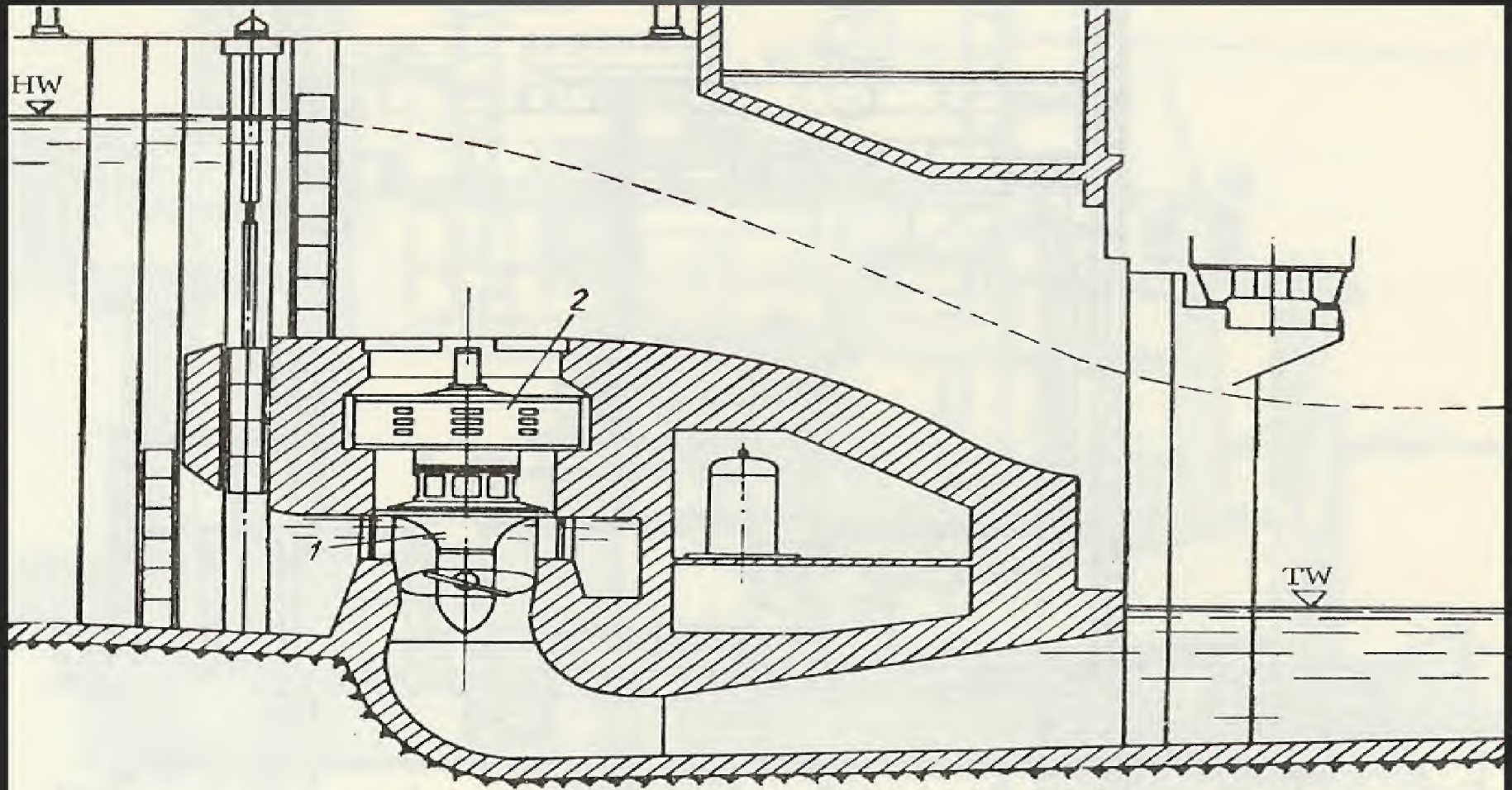
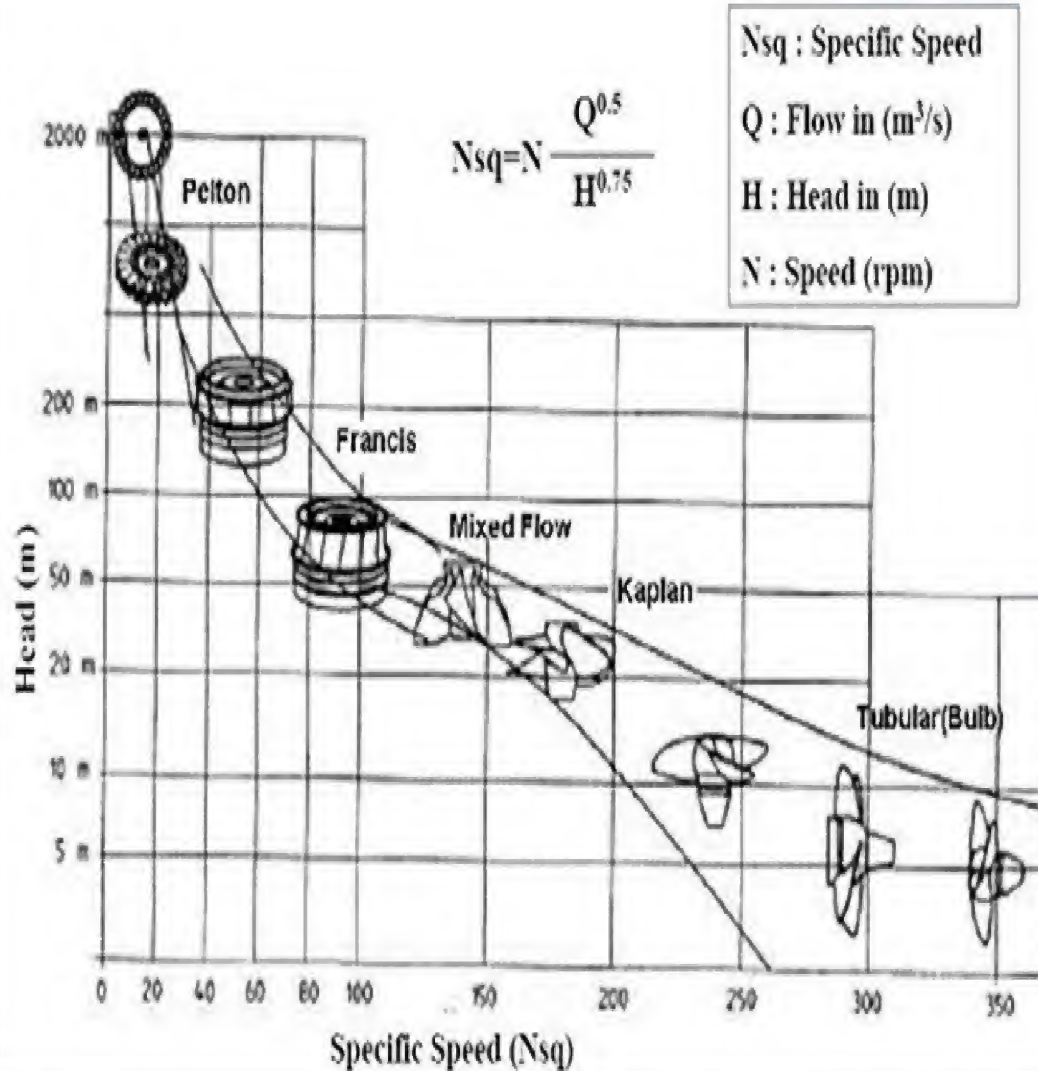


FIGURE I.3. Low-head hydroelectric plant with the generating unit located in the dam

# Performance Comparisons



Water-Supply and Irrigation Paper No. 180

Series M, General Hydrographic Investigations, 18

DEPARTMENT OF THE INTERIOR  
UNITED STATES GEOLOGICAL SURVEY  
CHARLES D. WALCOTT, DIRECTOR

## TURBINE WATER-WHEEL TESTS

AND

## POWER TABLES

BY

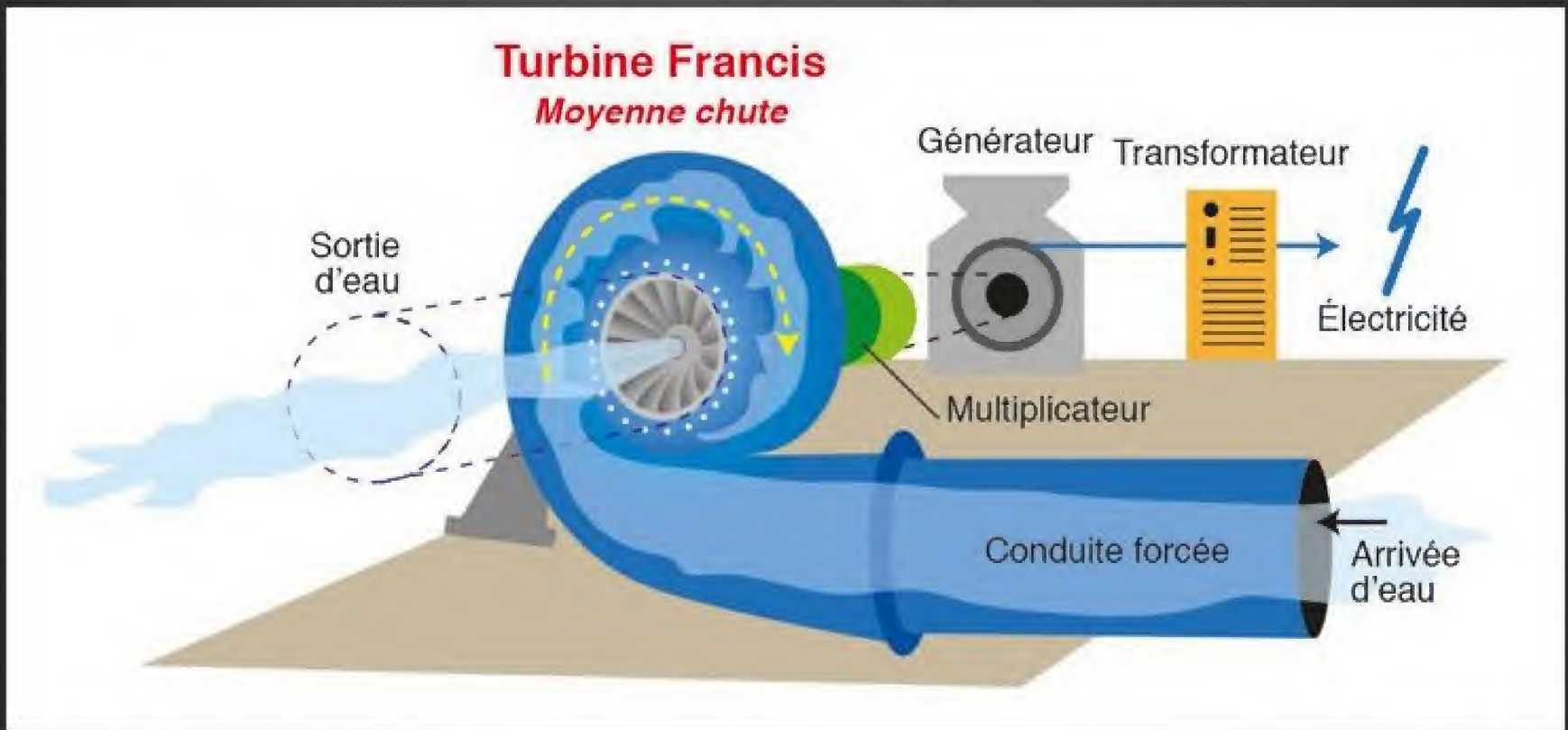
ROBERT E. HORTON



WASHINGTON  
GOVERNMENT PRINTING OFFICE  
1906



# A couple illustrations re: getting rid of the water after it has done it's work



# Theories Did Abound

(With a little consternation!)

## 22

**There are two good reasons for preferring such wheels : First, a good part gate wheel uses water in proportion to the work it has to do, and there are times in all mills when more or less of the work is stopped. Good part gate wheels save water at such times, which benefits all on the same fall ; but a more important point is, that during low water in the dry season, when the supply is insufficient to do the work without the aid of steam, the mill having good part gate wheels can utilize whatever there is of water, while those having Boyden, or any of the popular whole gate wheels, can realize but little benefit from a two-thirds, and nothing from a half supply.**

**There is one, and only one, method of securing a valuable turbine without any risk, and that is to ascertain first exactly what is needed, which may readily be done by measuring the water that is to be used and the power the mill requires ; then apply to a respectable turbine builder, use ordinary common sense in the**

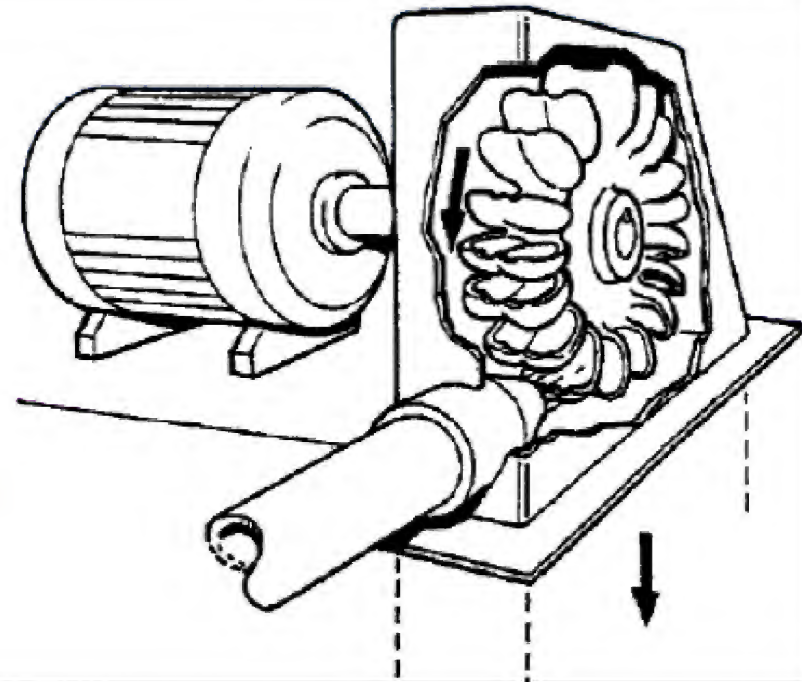
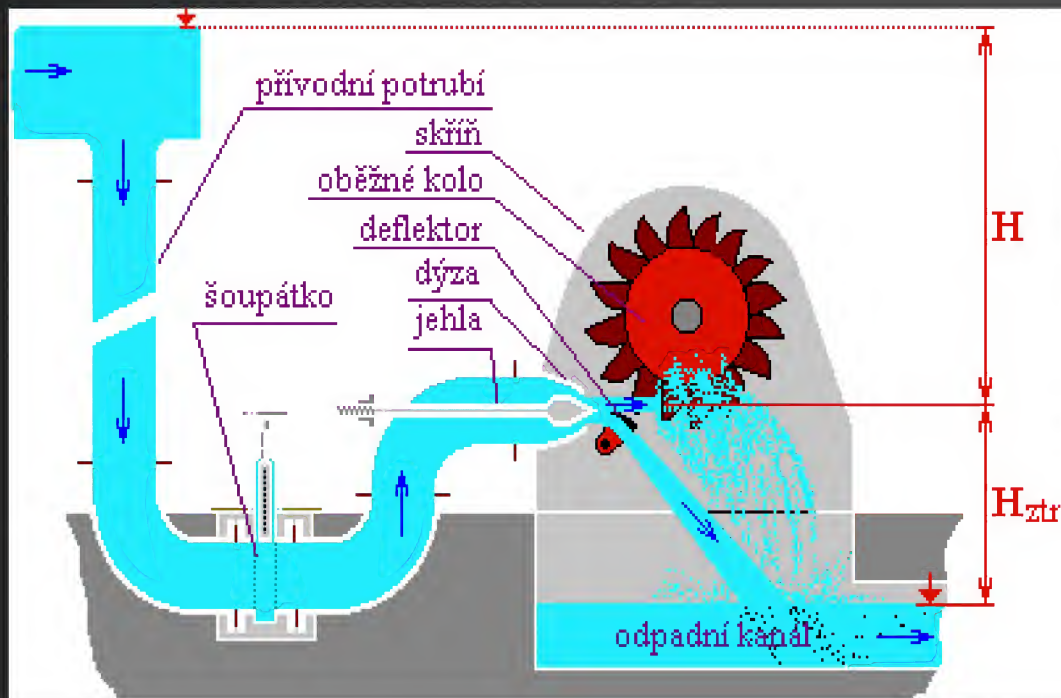


# “IN A COW’S NOSE...?”



Pelton's discovery of the power possibilities  
contained in the shape of a cow's nose

# AHHH! H<sub>2</sub>O 'Squirts In', 'Works', 'Falls Away', 'Flows Out' PELTON = SIMPLICITY





# Alas, Tonight's Focus...

## **COW THAT ASSISTED SCIENCE.**

---

One day in the summer of 1860, a miner toiled on his claim at North Bloomfield, in the United States, washing the gold-bearing gravel. For this purpose he had provided a long length of ordinary hose. As the fall from above was considerable, the water gushed from the hose with great force.

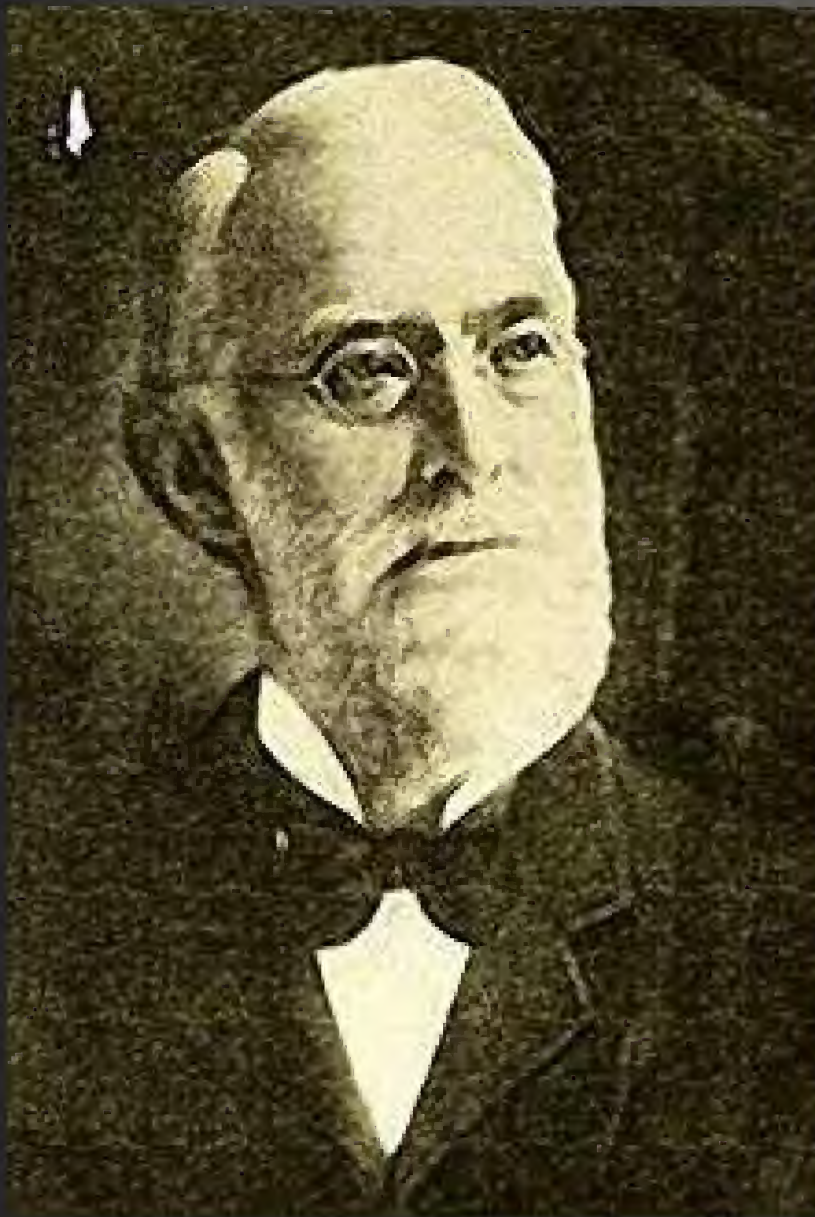
Then a simple thing happened which ultimately provided the world with a wonderful invention. A cow came down to the workings to quench her thirst, and was in danger of upsetting some of the sluices. The miner turned the hose on her, and by chance the water struck the animal in her cup-like nostrils, throwing her head back sharply.

The miner was impressed by the effect the water had when it came in contact with the cow's nose. Within an hour he was rigging up a waggon wheel with empty cans. Such was the beginning of the Pelton Water Wheel, which forms the basis of the great turbines which transform water into electric energy.

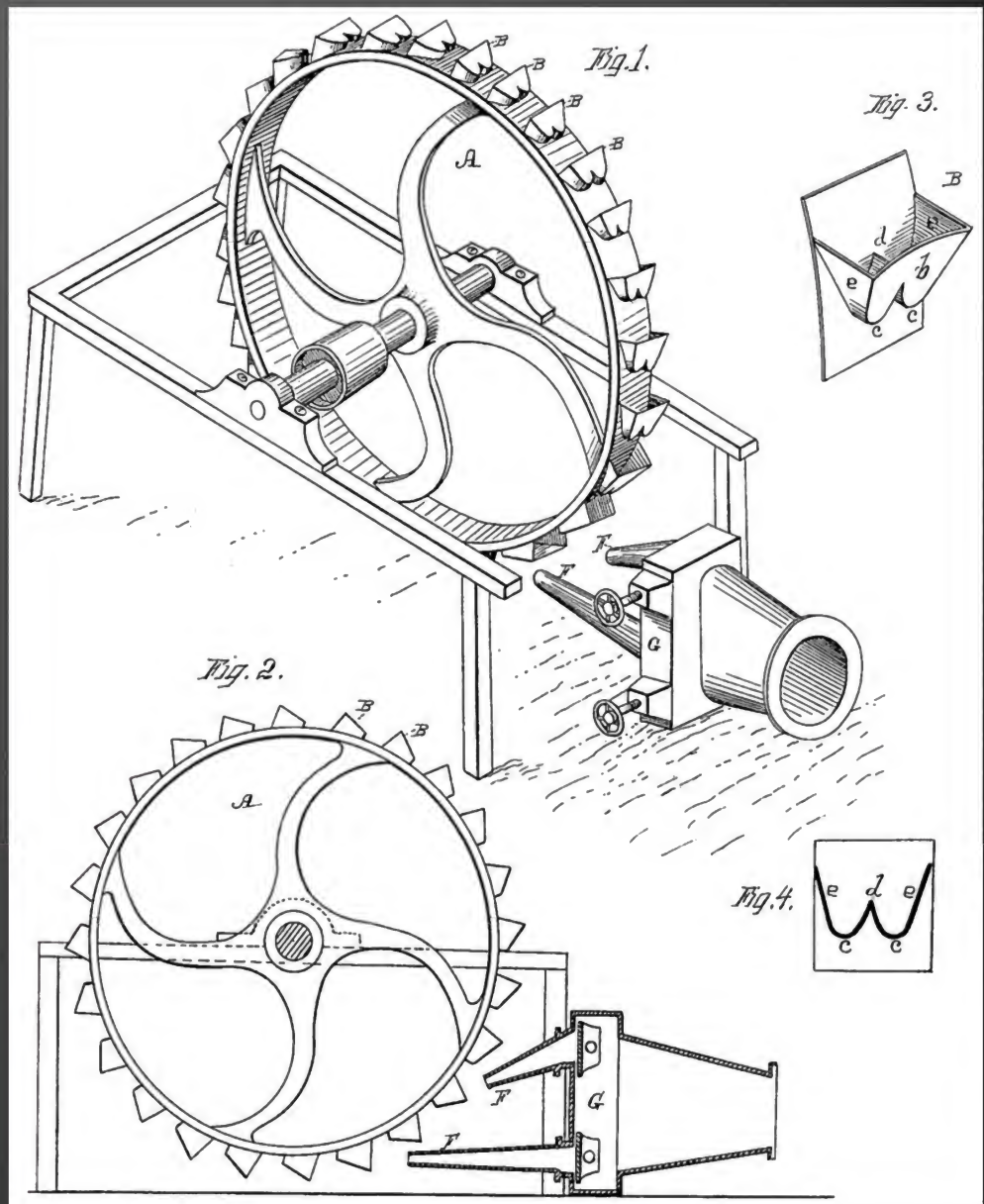
The miner was Lester A. Pelton, and while still working on his claim he built a model of his invention. Success did not come his way until 1885, when the machine was exhibited at San Francisco, and business men provided the necessary funds for its manufacture for commercial use.

---





Lester Allan Pelton



Patent Drawing



# **Lester Allan Pelton**

(September 5, 1829 – March 14, 1908)

**Was an American inventor who contributed significantly to the development of hydro-power and hydroelectric power in the old West and world-wide.**

**In the late 1870's, he invented the Pelton Water Wheel, at that time the most efficient design of the impulse water turbines.**

**Recognized as one of the fathers of hydroelectric power, he was awarded the Elliott Cresson Medal during his lifetime and recently inducted into the National Inventor's Hall of Fame.**

# Early Life, Youth, Death and Legacy

Lester A. Pelton was born in a log cabin in rural Vermillion Township, Erie County, Ohio. His grandfather, Captain Josiah Pelton, who lost most of his assets as a sea captain during the War of 1812 era, shortly later brought his family to Ohio.

Lester's father was Allen Pelton, and his mother was Fanny Cuddeback, from another local early pioneer family.

As a youngster, Lester worked on his family's farm and probably attended the nearby Cuddeback Grade School.

Pelton died in California at age 78, and is buried at his family site in Vermillion, Ohio.

His Pelton Runner design is still used today to produce hydroelectric power in the U.S. and around the world.

Later designs such as the Turgo turbine, first patented in 1919 and the Banki



# ON THE PELTON TURBINE

The Pelton impulse water turbine is which most water motors were based Water turbines and water wheels were not new, but Pelton's innovation was to shape the buckets on the wheel so that the impinging water was reversed in direction, thus extracting more energy from it.

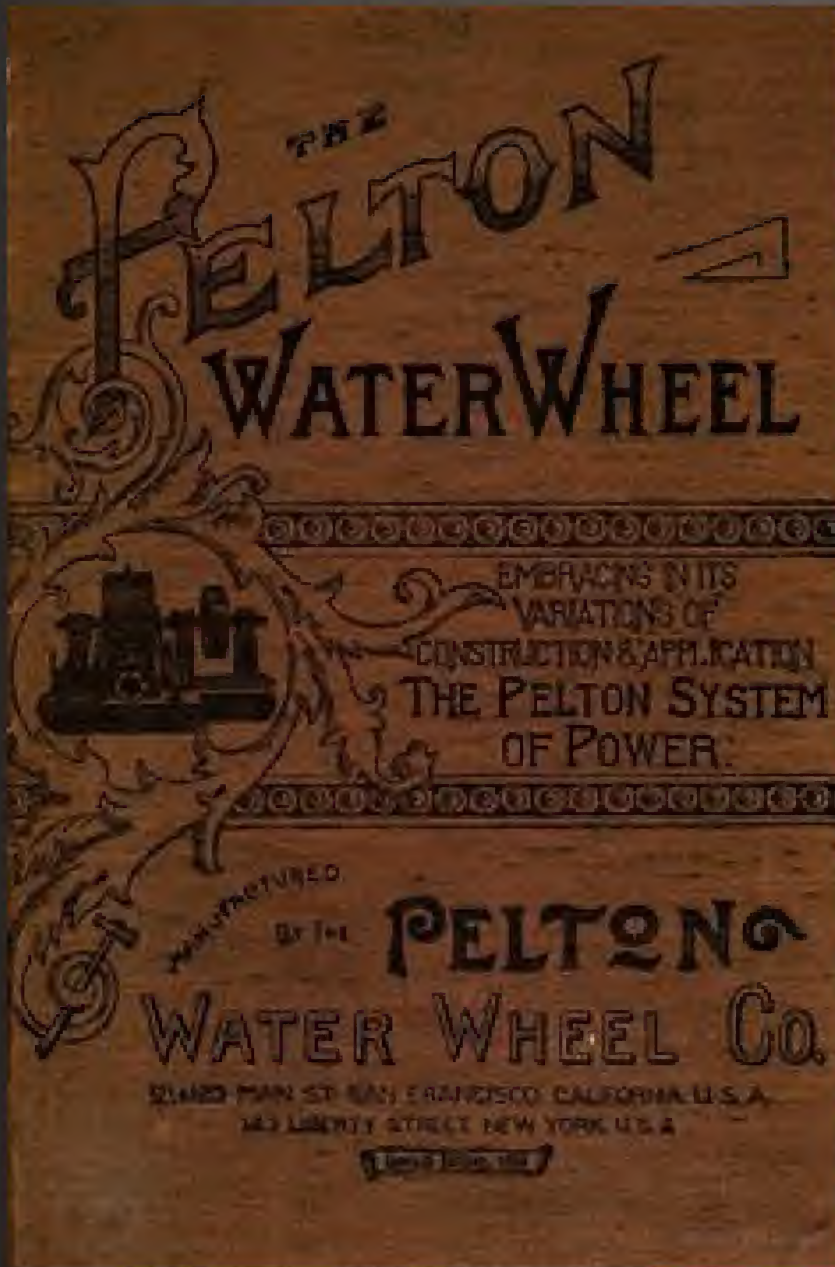
For greatest efficiency the buckets are receding at half the speed of the water so that the water is brought to a stop.

The Pelton wheel was first used at the Mayflower Mine in Nevada City, California in 1878. By 1879 he had tested a prototype Pelton wheel at the University of California.

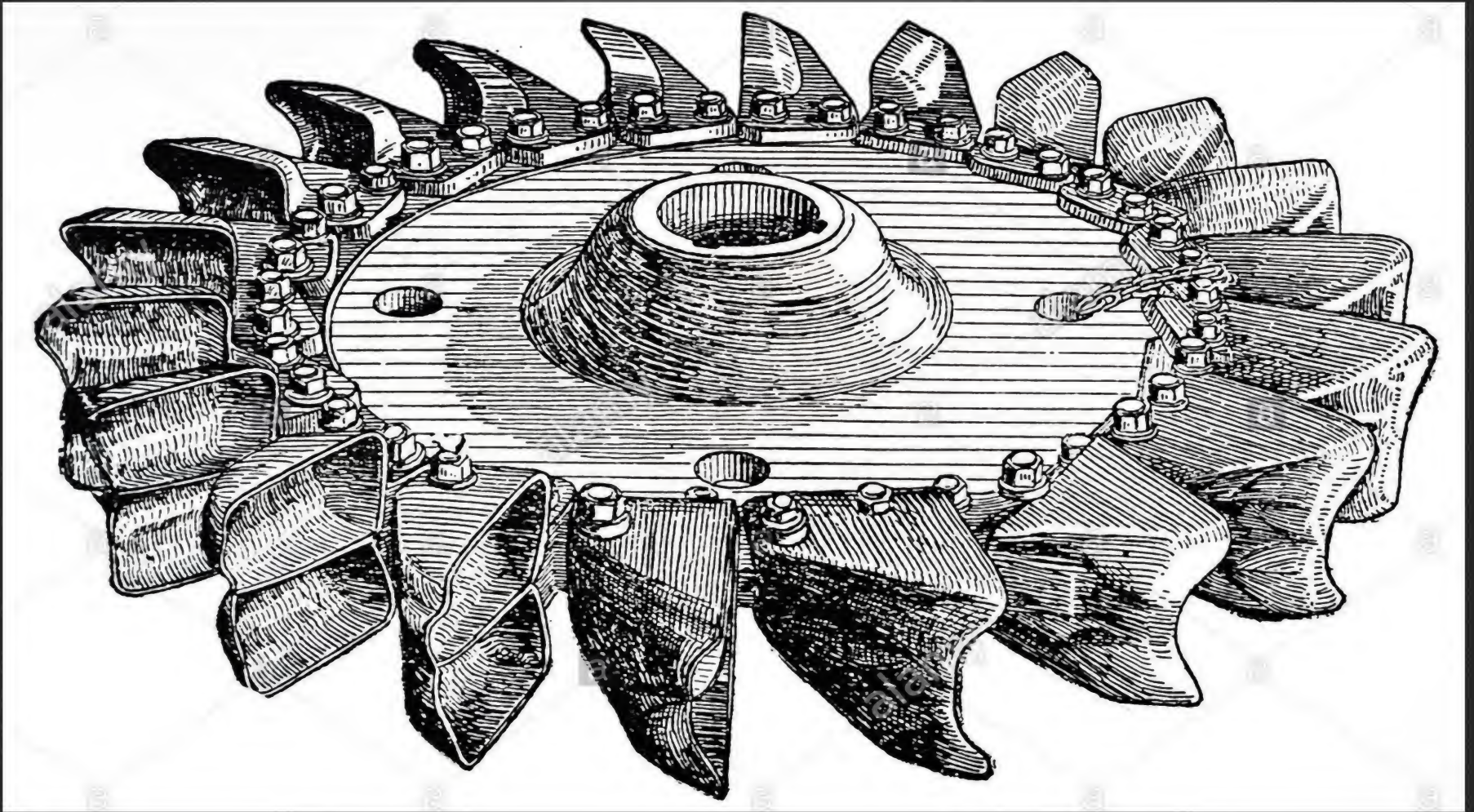
In 1887 a miner attached a Pelton wheel to a dynamo and thereby produced the first hydroelectric power in the Sierra Nevada Mountains.

The Pelton turbine works best with relatively small amounts of water at high pressure. It has a high energy conversion efficiency, usually over 90%.

# The PELTON Water Wheel



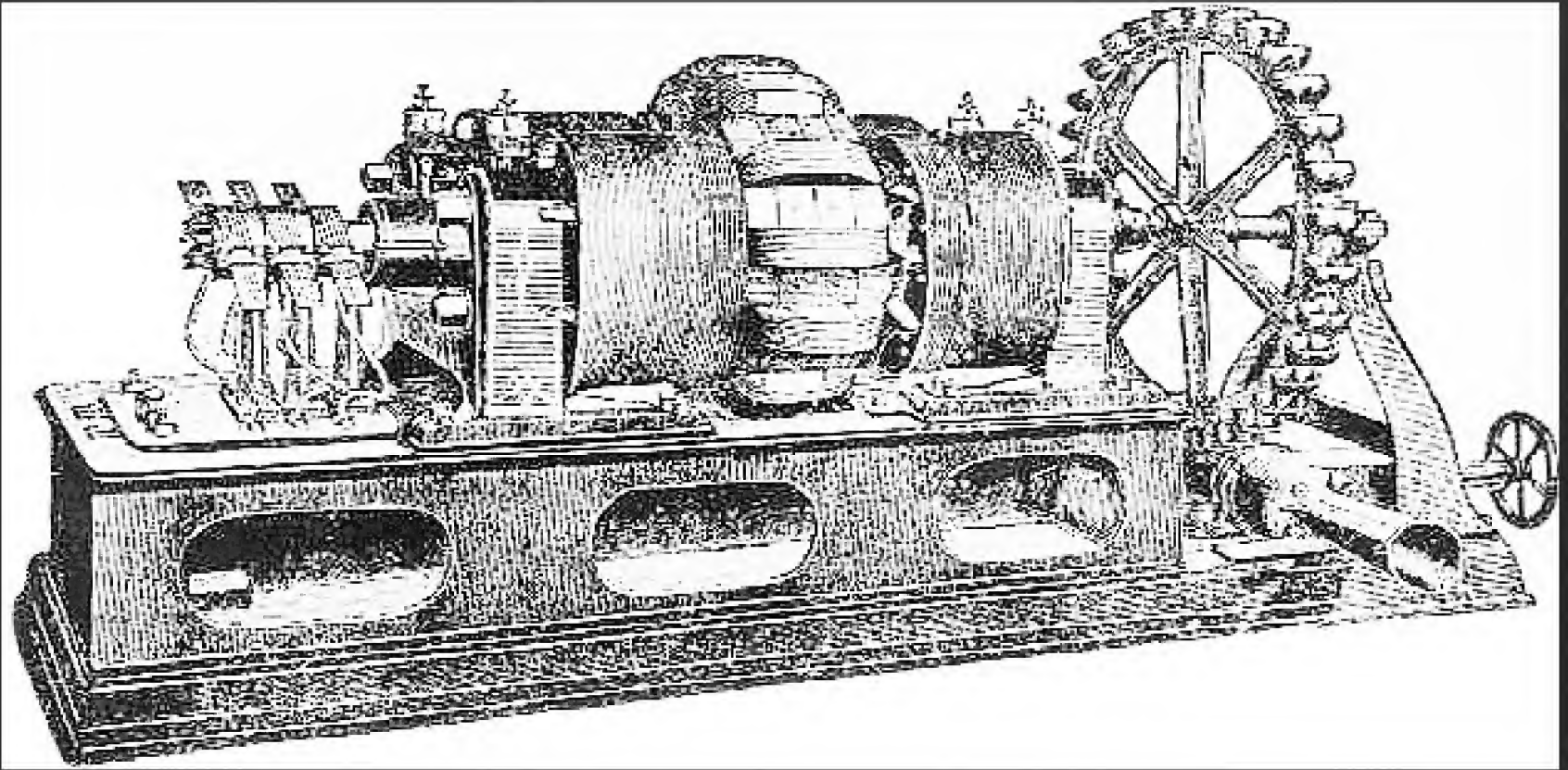




## Engraving depicting a Pelton Wheel

Showing the curved divided buckets attributed to Lester Allan Pelton. This form of impulse turbine was used during the second half of the nineteenth century





**Pelton Wheel shown used in an  
Electrical Generation Application**



# Ahhh... Such Simplicity

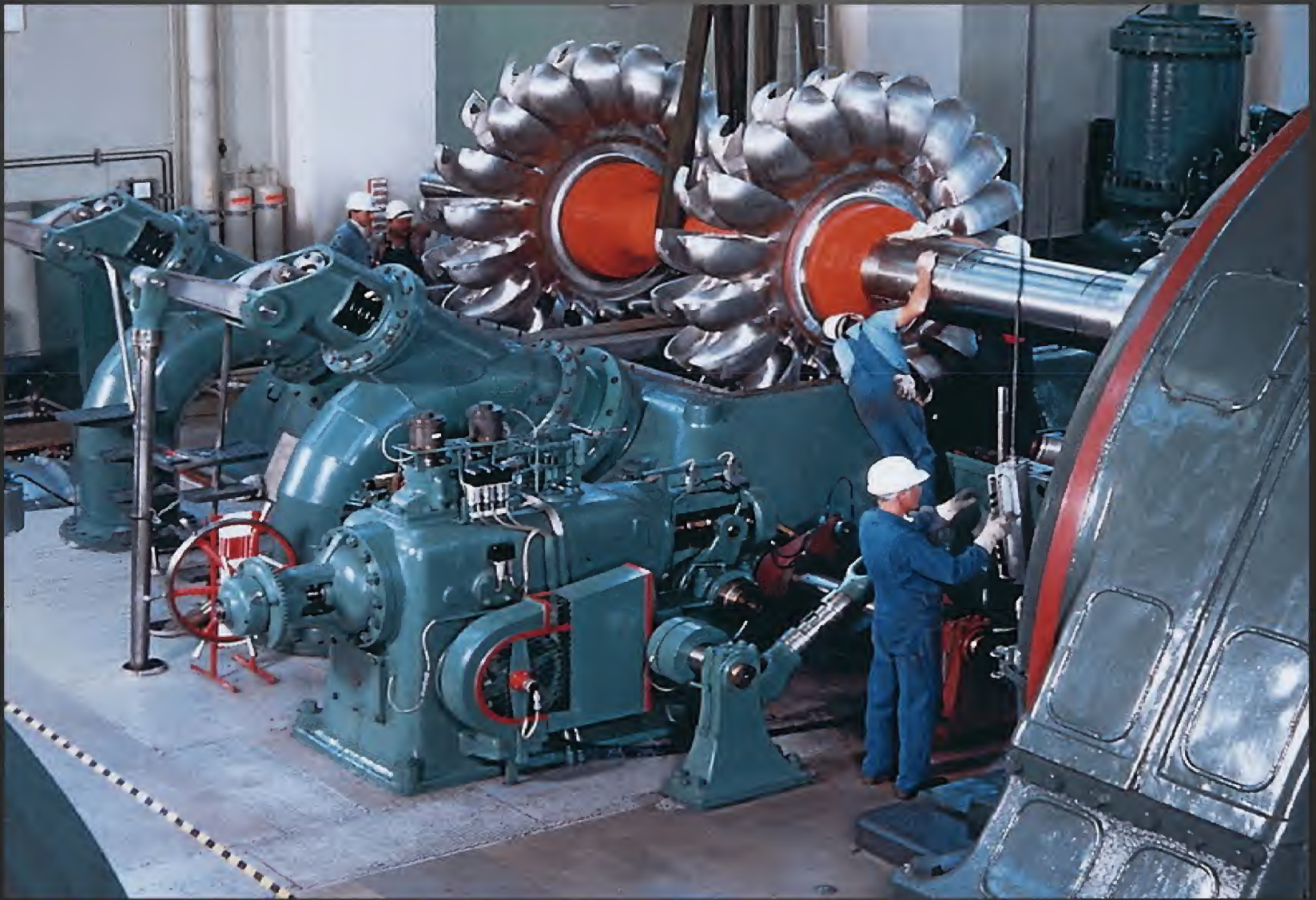
An Early Pelton Wheel (below) and the  
Cow's Nose Shaped 'Interchangeable'  
Part of a Modern Day Pelton Wheel  
(right)



# Some Pelton Wheels...



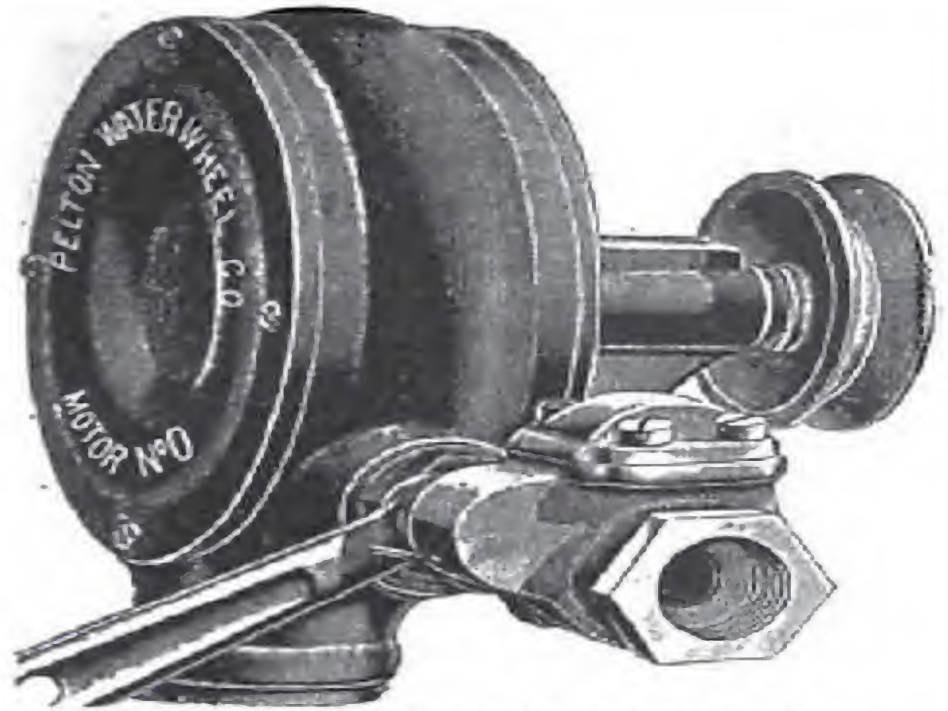




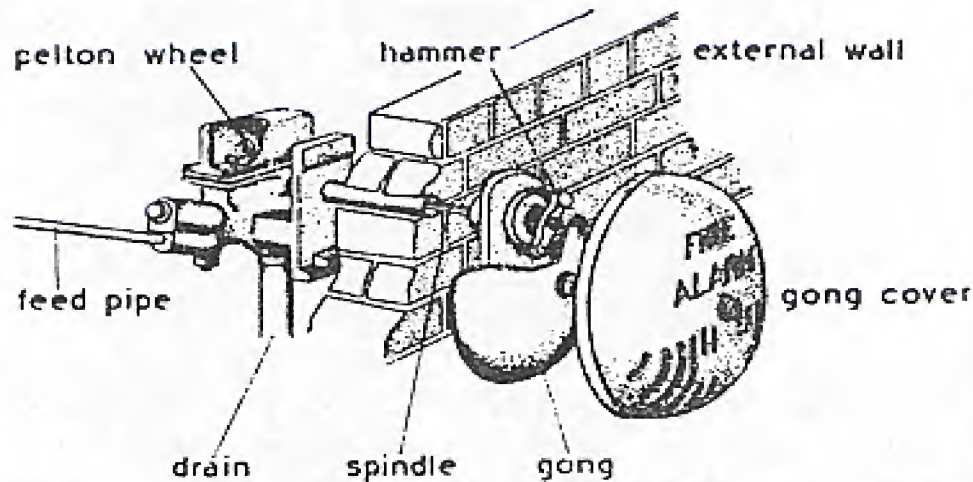
Assembly of a **Pelton Wheel** at Walchensee  
Hydroelectric Power Station, Germany

# Yesterdays...

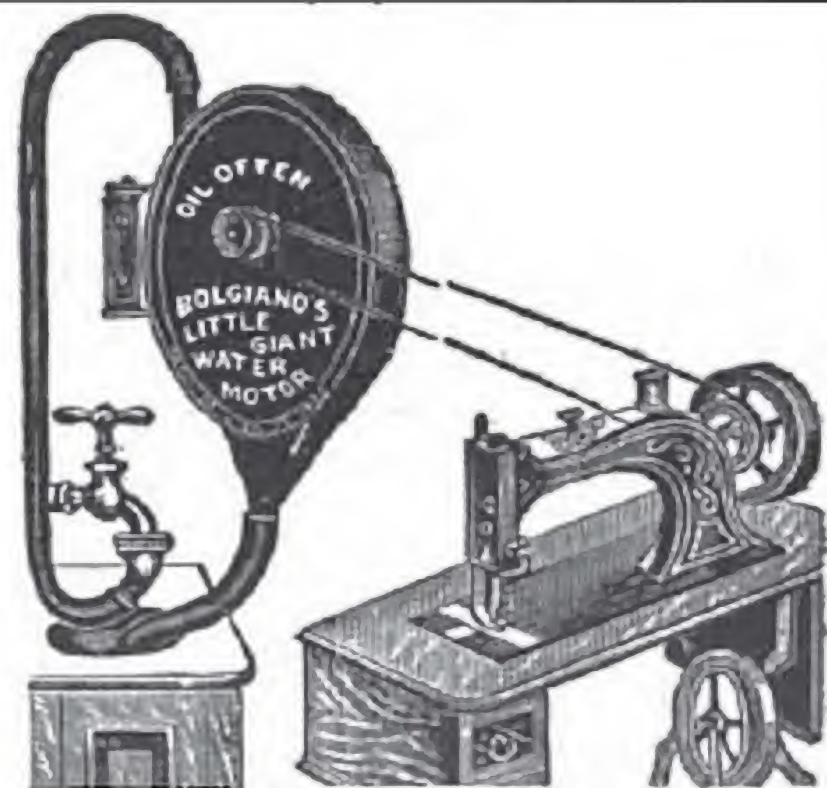
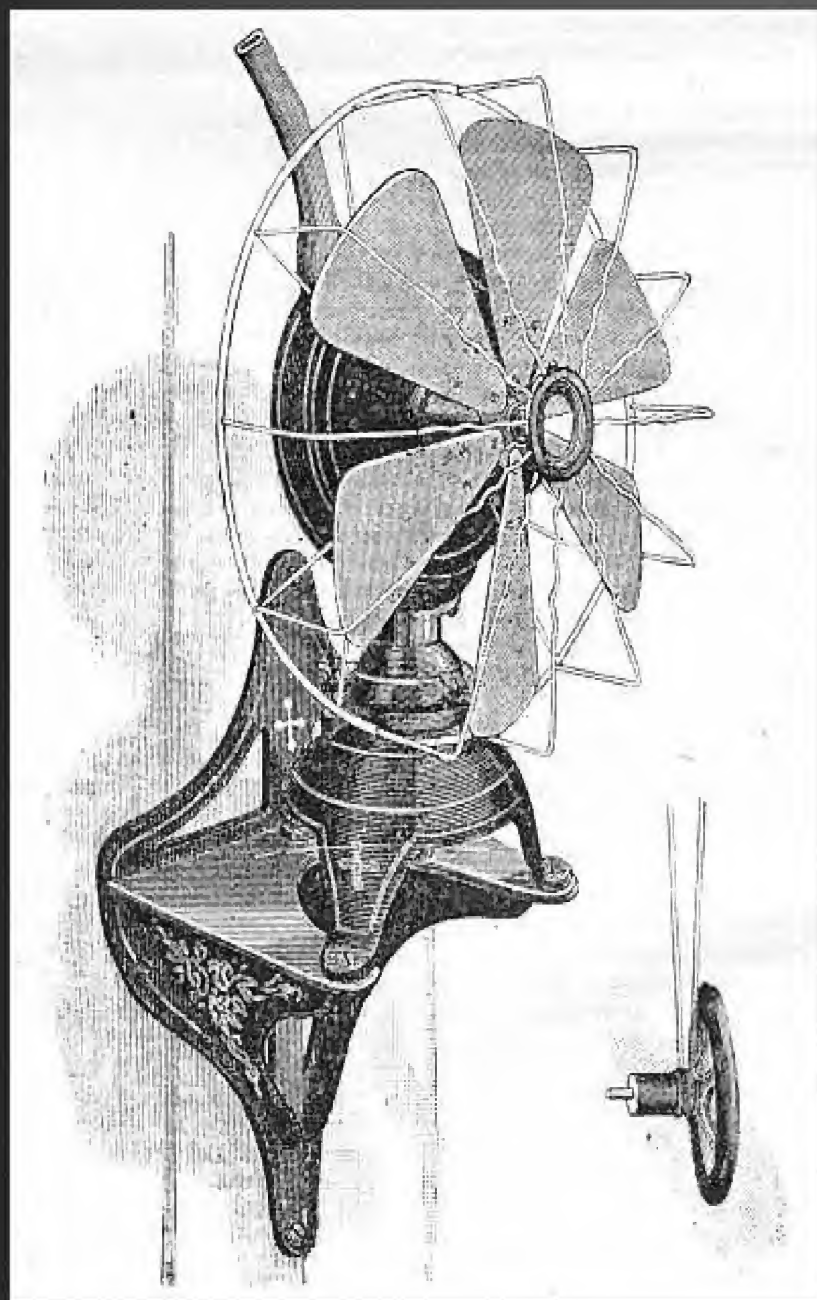
## Pelton Wheel Applications



**FIG. 1215. NO. 0 PELTON WATER MOTOR.**







**FIG. 1216. LITTLE GIANT WATER MOTOR.**

No. 1 Motor, price \$5.00 complete, has  $5\frac{1}{4}$  inch wheel, and is used for Sewing Machines, Fans, Scroll Saws, Dental Engines, Music Boxes, etc., etc.

No. 2 Motor, \$10.00 complete, used for Coffee Mills, Pea-Nut Roasters, Small Printing Presses, Ice Cream Freezers, etc.

The Water Motor shown above can be used to good advantage for light work; it is low in price, and is sold and used quite extensively.

# North Bloomfield California History

First named "Humbug" in 1851 by unlucky miners, North Bloomfield was a placer camp that served as a supply base for the diggings, and grew into a booming town of about 1,229 during the height of hydraulic operations at Malakoff Diggins. Hydraulic mining was effective and profitable, but it severely damaged the environment.

Tailings from the mines destroyed farmlands, raised the bed of the Yuba River higher than the level of the city, and disrupted navigation of the Sacramento River and San Francisco Bay.

In 1884 a law was passed and Judge Lorenzo Sawyer halted the practice of hydraulic mining with a permanent injunction against dumping tailings into state's waterways..

Submitted by: Rena Furbert



# North Bloomfield Hydraulic Mining





# North Bloomfield Eroded Cliffs and Tailings



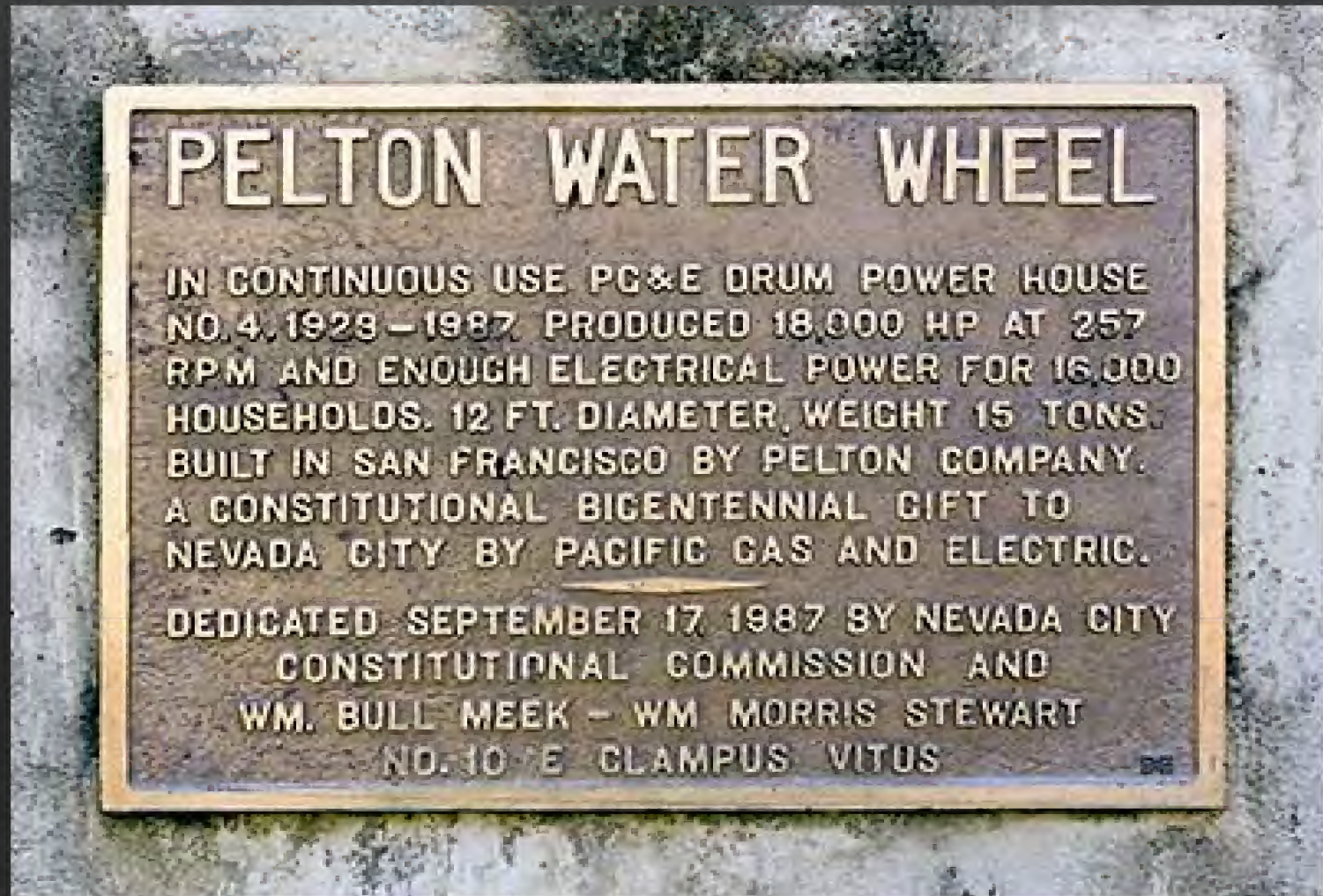


# North Bloomfield Water Cannon Relic





# Speaks for itself...





## And yet another tribute



### **PELTON WHEEL MANUFACTURING SITE**

THE PELTON WATER WHEEL, FIRST COMMERCIALY MANUFACTURED HERE AT GEORGE ALLAN'S FOUNDRY & MACHINE WORKS IN 1879, WAS A MAJOR ADVANCEMENT IN WATER POWER UTILIZATION AND GREATLY ADVANCED HARD-ROCK MINING. ITS UNIQUE FEATURE WAS A SERIES OF PAIRED BUCKETS, SHAPED LIKE BOWLS OF SPOONS AND SEPARATED BY A SPLITTER, THAT DIVIDED THE INCOMING WATER JETS INTO TWO PARTS. BY THE LATE 1800s, PELTON WHEELS WERE PROVIDING ENERGY TO OPERATE INDUSTRIAL MACHINERY THROUGHOUT THE WORLD. IN 1888, LESTER PELTON MOVED HIS BUSINESS TO SAN FRANCISCO, BUT GRANTED CONTINUING MANUFACTURING RIGHTS TO ALLAN'S FOUNDRY, WHERE THE WHEELS WERE MANUFACTURED INTO THE EARLY 1900s, WHEN MOST LOCAL MINES SHIFTED TO ELECTRIC POWER.

CALIFORNIA REGISTERED HISTORICAL LANDMARK NO. 1012

PLAQUE PLACED BY THE STATE DEPARTMENT OF PARKS AND RECREATION IN COOPERATION WITH THE NEVADA COUNTY CULTURAL PRESERVATION TRUST AND PACIFIC GAS & ELECTRIC CO., MAY 11, 1994.

Parting  
thought...  
“Always  
something new!”

A FISH  
FRIENDLY  
RUNNER





# “IN A COW’S NOSE...?”

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